Multi-jet measurements at D0

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Abstract. We presents the measurements of the dijet and three-jet inclusive invariant mass cross sections from the D0 experiment at the Fermilab Tevatron Collider.

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INTRODUCTION

Jet production has one of the largest cross sections of any inelastic processes at hadron colliders. It is therefore an ideal process to test the predictions of perturbative Quantum chromodynamics (pQCD). In this proceedings paper, we present the measurements of the dijet [1] and three-jet invariant mass cross sections [2] from the D0 experiment at the Fermilab Tevatron Collider. These measurements test the NLO pQCD matrix elements, the parton distribution functions (PDFs) and the strong coupling constant (α_S). The distinction of the two measurements is the different sensitivity of the two to the product of the strong coupling constant and the PDFs due to one additional vertex in the three-jet diagrams.

DATA SELECTION

Both analyses use a subsample of data collected in $p\bar{p}$ collisions at $\sqrt{s} = 1.96\,\mathrm{TeV}$ in Run II by the D0 detector. The detailed detector description is given in [3]. The integrated luminosity of the data sample is about $700\,\mathrm{pb}^{-1}$. The data sample is selected using either inclusive jet or dijet mass triggers. Triggers are generaly used in regions where they are at least 99% efficient. Jets are reconstructed using the D0 cone jet algorithm [4] with the radius $R = \sqrt{(\Delta y)^2 + (\Delta \phi)^2} = 0.7$. Both analyses share a large part of the framework for determining the unfolding correction. These corrections are estimated using a fast parameterized detector simulation. The events generated in PYTHIA (SHERPA) for dijet (three-jet) measurements are smeared using the detector resolutions which were measured in the real data and the unfolding coefficients are determined by comparing the original and smeared distributions. The total systematic uncertainty (dominated by the jet energy scale (of the order of 10–30%), luminosity (6.1%) and jet

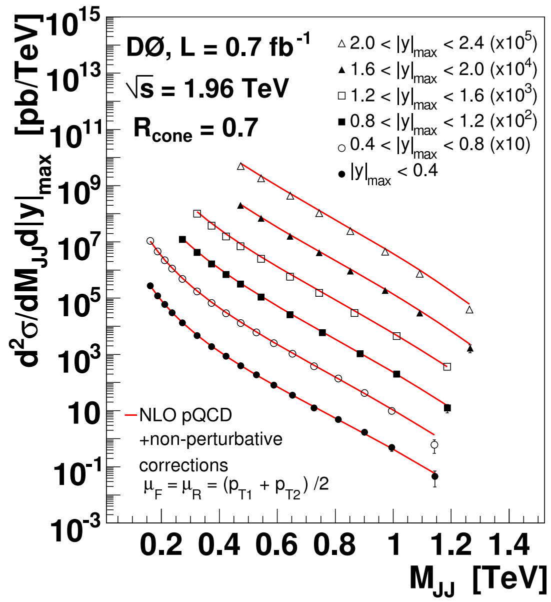

FIGURE 1. Dijet invariant mass spectrum in six bins of the maximum jet rapidity in agreement with the prediction of NLO pQCD (MSTW2008NLO PDF, shown in red line).

transverse momentum resolution (up to $\sim 5\%$)) is also determined in the simulation.

The NLO predictions for both analyses are computed using FASTNLO[5]. The PDF dependence of the predictions is studied by using different PDF sets. The scale dependence is studied by varying the renormalization and factorization scales up and down by a factor of two from the central value.

DIJET INVARIANT MASS

The dijet invariant mass (M_{JJ}) is computed from the four-vectors of the two jets with the highest transverse momenta in the event. Both jets are required to have $p_T > 40\,\text{GeV}$ and $|y| < 2.4$. There are 6 bins of jet rapidities, binned according to the higher rapidity of the two jets ($|y|_{\text{max}}$). The dijet invariant mass cross section is presented in Fig. 1 while the details of the analysis can be found in [1]. Good agreement with the NLO pQCD calculation is observed across the whole dijet mass range where the cross section falls by more than five orders of magnitude.

THREE-JET INVARIANT MASS

The three-jet invariant mass ($M_{3\text{jet}}$) is calculated using the three jets with the highest transverse momenta in the event. The basic event selection cuts are $p_T^{1\text{st}} > 150\,\text{GeV}$, $p_T^{3\text{rd}} > 40\,\text{GeV}$, $|y|_{\text{jet}} < 2.4$ and all three jets are required to be separated in $\Delta R = \sqrt{(\Delta y)^2 + (\Delta\phi)^2} > 1.4$. Further requirements on the jet transverse momenta and rapidities select five different analysis regions (three regions studying the rapidity dependence

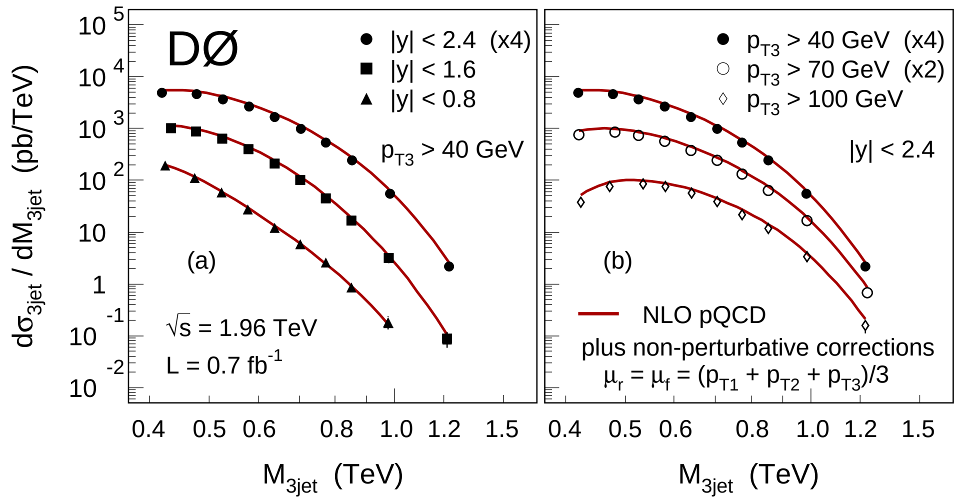

FIGURE 2. Three-jet invariant mass spectrum in three regions of the jet rapidities (left) and three regions of the jet transverse momenta (right).

and three regions of the transverse momentum of the third jet, one region is common to both).

The predictions of the NLO pQCD are again compared to the data and are found to be in a good agreement. For the three-jet cross section, several different PDF sets (MSTW2008NLO, CT10, NNPDFv2.1, HERAPDFv1.0 and ABKM09NLO) are used. We form a χ^2 between the data and the theory predictions in order to quantify the agreement. All statistical and systematical uncertainties are taken into acount in the χ^2 calculation except the PDF uncertainty, making the χ^2 effectively a test of the central PDFs only. We calculate the χ^2 for several values of the strong coupling constant (except for ABKM09NLO which provides a PDF set only for one value of α_S) and also for three different renormalization and factorization scales. The lowest χ^2s are obtained for $\alpha_S(M_Z) = 0.121$ (0.123) for MSTW2008NLO (NNPDFv2.1) PDFs for the central value of the scales (equal to the average transverse momentum of the three jets). This test demonstrates the PDF sensitivity to the three-jet cross section data.

SUMMARY

We present the measurements of the dijet and three-jet invariant mass cross sections from the D0 experiment. The results are in a good agreement with the prediction of the NLO pQCD. The data can be used for constraining of the parton distribution functions. We demonstrate the PDF sensitivity in the three-jet cross section.

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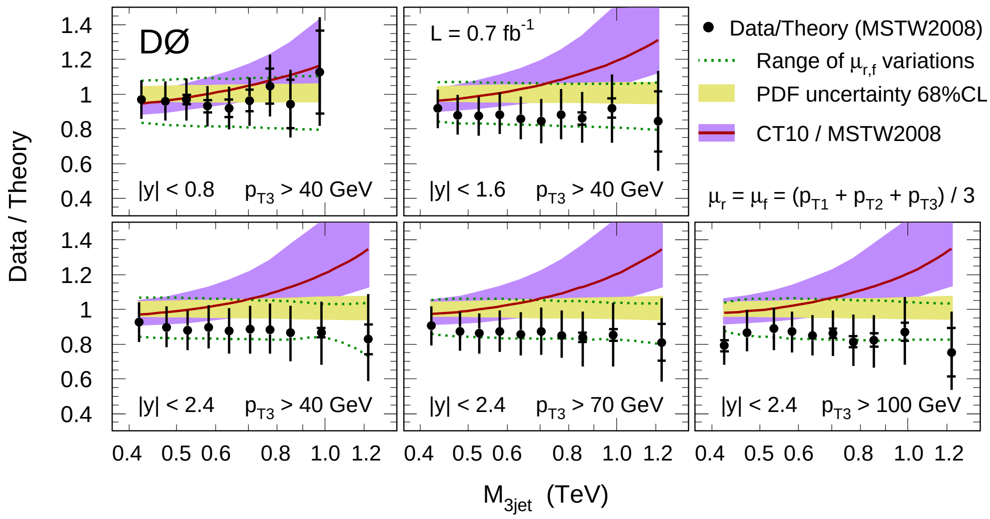

FIGURE 3. The data over theory ratio for the three-jet invariant mass cross section showing the range of the scale variation (green dotted lines), MSTW2008NLO PDF uncertainty (yellow band) and CT10 prediction (red line and violet band).

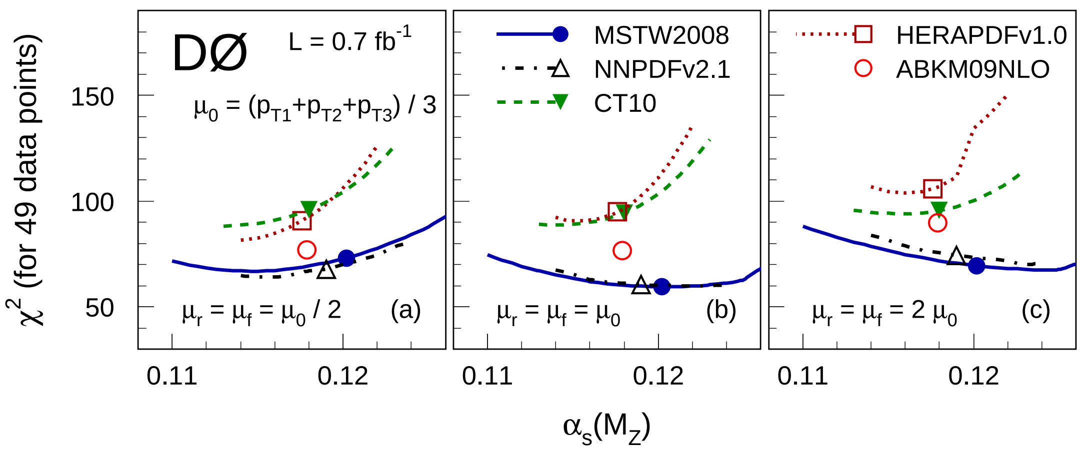

FIGURE 4. The χ^2 calculation between the data and various PDF predictions showing that the data prefers the MSTW2008 and NNPDFv2.1, the central value of the renormalization and the factorization scales and the default strong coupling constant value for each PDF set.

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